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### (54) Rotary shaft lubricating structure

Schmierungsanlage für eine rotierende Welle

Structure de lubrification d'un arbre rotatif

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## Description

### BACKGROUND OF THE INVENTION

#### 1. FIELD OF THE INVENTION

[0001] The present invention relates to a rotary shaft lubricating structure for lubricating a plurality of rotary shafts by supplying oil from an upstream side to a downstream side of a lubricating oil passage defined in a bearing block, the upstream-side rotary shafts being supported respectively in a plurality of upstream-side annular bearing members which have first and second oil bores at locations spaced apart from one another through a predetermined angle and which are fixed in a plurality of bearing bores defined in the bearing block, the lubricating oil passage passing through the bearing bores.

#### 2. DESCRIPTION OF THE RELATED ART

[0002] Such a rotary shaft lubricating structure is already known from Japanese Utility Model Publication No.64-3847 showing the prior art according to the preamble of claim 1. In the structure described in this publication, first and second bearing members (bushings) for supporting journal portions of first and second balancer shafts have different shapes. The first bearing member located upstream of the lubricating oil passage (i.e., lubricating oil supply passage) has two oil bores communicating with the lubricating oil passage, and the second bearing member located downstream of the lubricating oil passage has a single oil bore communicating with the lubricating oil passage. Therefore, the oil supplied from the upstream side of the lubricating oil passage passes through the two oil bores of the first bearing member to lubricate the journal portion of the first balancer shaft and then passes through the single oil bore of the second bearing member to lubricate the journal portion of the second balancer shaft. At this time, the downstream end of the lubricating oil passage is closed by the second bearing member having the single oil bore and hence, it is unnecessary to close the downstream end of the lubricating oil passage by a special blind plug, leading to a reduced number of parts.

[0003] However, the above known structure suffers from a disadvantage in that the shapes (the number of the oil bores) of the first and second bearing members must differ from each other, resulting in an increased number of types of parts, which require an increase in both manufacturing and management costs.

#### SUMMARY OF THE INVENTION

[0004] Accordingly, it is an object of the present invention to ensure that the downstream end of the lubricating oil passage can be closed by a single type of bearing member without using a special closing member such

as a blind plug.

[0005] To achieve the above object, according to the present invention, there is provided a rotary shaft lubricating structure as defined by claim 1.

[0006] With such an arrangement, the downstream end of the lubricating oil passage can be closed without using a special closing member only by preparing the plurality of bearing members having the same shape and by setting the angle of fixing of the downstream end-side bearing member located at the downstream end portion in the oil supplying direction, so that the angle is different from those of the other bearing members, thereby reducing the number of parts. Moreover, it is unnecessary to manufacture a plurality of types of bearing members having different shapes, which can contribute to a reduction in cost. Further, when the bearing members are fixed at different angles, it is not restricted or hindered by the bearing bores in the bearing block, leading to an enhanced ease of assembly.

[0007] The above and other objects, features and advantages of the invention will become apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Figs.1 to 10 illustrate a first embodiment of the present invention, wherein

Fig.1 is a vertical sectional view of an engine;  
Fig.2 is a sectional view taken along a line 2-2 in Fig.1;  
Fig.3 is a view taken in a direction of an arrow 3 in Fig.2;  
Fig.4 is an enlarged view (a bottom view of a secondary balancer device) taken along a line 4-4 in Fig.2;  
Fig.5 is a sectional view taken along a line 5-5 in Fig.4;  
Fig.6 is a sectional view taken along a line 6-6 in Fig.4;  
Fig.7 is an enlarged sectional view taken along a line 7-7 in Fig.4;  
Fig.8 is a sectional view taken along a line 8-8 in Fig. 2;  
Fig.9 is an enlarged view of an essential portion in Fig.8;  
Fig.10 is a perspective view of a bearing bushing;  
Fig.11 is a view corresponding to Fig.9, but according to a second embodiment of the present invention; and  
Fig.12 is a view corresponding to Fig.9, but according to a third embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] The present invention will now be described by

way of preferred embodiments with reference to the accompanying drawings.

**[0010]** A first embodiment of the present invention will be first described with reference to Figs.1 to 10.

**[0011]** Referring to Figs.1 to 3, an engine E in the present embodiment is an in-line 4-cylinder engine which includes a crankshaft 1 disposed horizontally, and four cylinder axes 2 disposed substantially vertically. An engine body includes a cylinder head 3, a cylinder block 4 coupled to a lower surface of the cylinder head 3, a lower block 5 coupled to a lower surface of the cylinder block 4, and an oil pan 6 coupled to a lower surface of the lower block 5. #1, #2, #3, #4 and #5 journal portions 1<sub>1</sub>, 1<sub>2</sub>, 1<sub>3</sub>, 1<sub>4</sub> and 1<sub>5</sub> are clamped and rotatably supported between five journal support portions 4<sub>1</sub>, 4<sub>2</sub>, 4<sub>3</sub>, 4<sub>4</sub> and 4<sub>5</sub> formed on the lower surface of the cylinder block 4 and five journal support portions 5<sub>1</sub>, 5<sub>2</sub>, 5<sub>3</sub>, 5<sub>4</sub> and 5<sub>5</sub> formed on an upper surface of the lower block 5.

**[0012]** The lower surface of the lower block 5 is provided with an oil pump 7 comprised of a trochoidal pump and a secondary balancer device 8 for reducing the secondary vibration of the engine E. The oil pump 7 and the secondary balancer device 8 are immersed in an oil accumulated in the oil pan 6. The oil pan 6 has a depth at a location below the #1 journal portion 1<sub>1</sub> larger than that at a location below the #4 journal portion 1<sub>4</sub>, which is convenient for disposition of the oil pump 7.

**[0013]** As can be seen from Figs.4 to 6, a pump housing 9 of the oil pump 7 coupled to a lower surface of the journal support portion 5<sub>1</sub> of the lower block 5 is comprised of two members: a pump body 11 and a pump cover 12 which are integrally coupled to each other by five bolts 10. Six reinforcing ribs 12<sub>1a</sub> and 12<sub>1b</sub> project from a surface of the pump cover 12 opposite from the pump body 11 (see Fig.5). Not only the supporting rigidity for a rear balancer shaft 22, which will be described hereinafter, can be enhanced, but also a variation in oil level due to sloshing of the oil within the oil pan 6 can be suppressed, by the reinforcing ribs 12<sub>1a</sub> and 12<sub>1b</sub>. Particularly, the supporting rigidity for the rear balancer shaft 22 can be remarkably enhanced by the five reinforcing ribs 12<sub>1a</sub> radially formed on the journal support portions of the rear balancer shaft 22.

**[0014]** The pump body 11 includes an intake port 11<sub>1</sub> which opens into a mating surface thereof to the pump cover 12, a discharge port 11<sub>2</sub> and a pump chamber 11<sub>3</sub>. An inner rotor 15 meshed with an outer rotor 14 rotatably carried in the pump chamber 11<sub>3</sub> is coupled to and driven by a pump shaft 16 rotatably carried in the pump body 11.

**[0015]** An oil strainer 17 is provided for filtering the oil within the oil pan 6 to supply the filtered oil to the intake port 11<sub>1</sub> of the oil pump 7, and has a mounting flange 17<sub>1</sub> which is fastened to the pump cover 12 by two of the five bolts 10 for coupling the pump cover 12 to the pump body 11. The oil discharged from the discharge port 11<sub>2</sub> of the oil pump 7 is supplied through an oil passage 11<sub>4</sub> to an oil gallery 13(see Fig.8) defined in the

cylinder block 4 and then supplied therefrom as a lubricating oil to various portions of the engine E.

**[0016]** Thus, the oil pump 7 having the above-described construction is coupled to the lower surface of the lower block 5 by two bolts 18, 18 passing through the pump body 11 below the #1 journal portion 1<sub>1</sub>, and by a single bolt 19 passing through the pump body 11 below between the #1 and #2 journal portions 1<sub>1</sub> and 1<sub>2</sub>, i.e., at a location offset toward a bracing journal portion 26<sub>4</sub>.

**[0017]** The secondary balancer device 8 includes a front balancer shaft 21 and a rear balancer shaft 22 which are rotated in opposite directions at twice the speed of the crankshaft 1. The front balancer shaft 21 is comprised of a shaft body 23 and a pair of cylindrical covers 24 and 25. The shaft body 23 includes a pair of balancer weight portions 23<sub>1</sub> and 23<sub>2</sub> eccentric from a rotational axis of the shaft body 23, a main journal portion 23<sub>3</sub> formed between both the balancer weight portions 23<sub>1</sub> and 23<sub>2</sub>, a bracing journal portion 23<sub>4</sub> formed at one of axial ends, and a driving helical gear 23<sub>5</sub> formed adjacently to the main journal portion 23<sub>3</sub>. The pair of cylindrical covers 24 and 25 are disposed coaxially with the rotational axis and fixed to the shaft body 23 so as to cover the pair of balancer weight portions 23<sub>1</sub> and 23<sub>2</sub>.

**[0018]** The rear balancer shaft 22 is also comprised of a shaft body 26 and a pair of cylindrical covers 27 and 28, as is the front balancer shaft 21. The shaft body 26 includes a pair of balancer weight portions 26<sub>1</sub> and 26<sub>2</sub> eccentric from a rotational axis of the shaft body 26, a main journal portion 26<sub>3</sub> formed between both the balancer weight portions 26<sub>1</sub> and 26<sub>2</sub>, a bracing journal portion 26<sub>4</sub> formed at one of axial ends, and a follower helical gear 26<sub>5</sub> formed adjacently to the main journal portion 26<sub>3</sub>. The pair of cylindrical covers 27 and 28 are disposed coaxially with the rotational axis and fixed to the shaft body 26 to cover the pair of balancer weight portions 26<sub>1</sub> and 26<sub>2</sub>.

**[0019]** By covering the balancer weight portions 23<sub>1</sub>, 23<sub>2</sub>; 26<sub>1</sub> and 26<sub>2</sub> with the cylindrical covers 24, 25; 27 and 28 in the above manner, the balancer weight portions 23<sub>1</sub>, 23<sub>2</sub>; 26<sub>1</sub> and 26<sub>2</sub> can be prevented from stirring the oil within the oil pan 6, thereby alleviating the rotational resistance of the front and rear balancer shafts 21 and 22.

**[0020]** As can be seen from Fig.7, a balancer holder 29 made of an iron-based material is coupled to a lower surface of the journal supporting portion 5<sub>3</sub> of the lower block 5 by two bolts 30, 30. The driving helical gear 23<sub>5</sub> of the front balancer shaft 21 and the follower helical gear 26<sub>5</sub> of the rear balancer shaft 22 are accommodated in a meshed relation within a gear chamber 29<sub>1</sub> defined in a balancer holder 29. A thrust plate 31 for limiting the axial movement of the front and rear balancer shafts 21 and 22 is fixed to the balancer holder 29 by three bolts 32 to cover an opening in the gear chamber 29<sub>1</sub>. An oil releasing bore 31<sub>1</sub> is defined in a central portion

of the thrust plate 31, so that a hydraulic pressure generated within the gear chamber 29<sub>1</sub> by meshing of the driving helical gear 23<sub>5</sub> with the follower helical gear 26<sub>5</sub> is released through the oil releasing bore 31<sub>1</sub>.

[0021] The driving and follower helical gears 23<sub>5</sub> and 26<sub>5</sub> are provided between the main journal portions 23<sub>3</sub> and 26<sub>3</sub> and the bracing journal portions 23<sub>4</sub> and 26<sub>4</sub> of both the balancer shafts 21 and 22 and in proximity to the main journal portions 23<sub>3</sub> and 26<sub>3</sub>, respectively, leading to a very good meshing accuracy. In addition, since the thrust plate 31 is formed from a single member and hence, a reduced number of parts are required, and it is easy to attach the thrust plate 31. The oil releasing bore 31<sub>1</sub> is provided at a location where the pressure in the gear chamber 29<sub>1</sub> is greater, and below the gear chamber 29<sub>1</sub>, which is convenient for releasing of the oil. Further, because the balancer holder 29 is made of the iron-based material having a small thermal coefficient of expansion, the variation in distance between axes of the balancer shafts 21 and 22 can be minimized, thereby preventing the generation of an abnormal sound due to a failure of meshing of the helical gears 23<sub>5</sub> and 26<sub>5</sub>.

[0022] As can be seen from Fig.4, the bracing journal portion 23<sub>4</sub> of the front balancer shaft 21 is supported in a bearing bore 11<sub>5</sub> defined in the pump body 11, and the bracing journal portion 26<sub>4</sub> of the rear balancer shaft 22 is supported in a bearing bore 12<sub>2</sub> defined in the pump cover 12. The pump shaft 16 of the oil pump 7 and the rear balancer shaft 22 are disposed coaxially with each other, and an oil chamber 12<sub>3</sub> is defined in the pump cover 12 to communicate with the axial end of the pump shaft 16 through an oil passage 12<sub>4</sub>, so that the axial end of the bracing journal portion 26<sub>4</sub> (see Fig.4) of the rear balancer shaft 22 faces the oil chamber 12<sub>3</sub>.

[0023] In this way, each of the balancer shafts 21 and 22 is supported at two places: first, at the lengthwise central main journal portion 23<sub>3</sub>, 26<sub>3</sub> and second, at the bracing journal portion 23<sub>4</sub>, 26<sub>4</sub> at the axial end, respectively. Hence, the vibration of both the balancer shafts 21 and 22 with the rotation can be reliably prevented. Moreover, since the bracing journal portion 26<sub>4</sub> of the rear balancer shaft 22 is supported in the bearing bore 12<sub>2</sub> in the pump cover 12, the length of the rear balancer shaft 22 is shortened and hence, the balancer shaft 22 can be supported in a more stable manner. Further, since the pump body 11 is coupled to the lower surface of the lower block 5 by the bolt 19 at the location offset toward the bracing journal portion 26<sub>4</sub>, leading to a remarkably enhanced supporting rigidity for the rear balancer shaft 22.

[0024] Lubrication of the front and rear balancer shafts 21 and 22 supported on the balancer holder 29 will be described below with reference to Figs.8 to 10.

[0025] As shown in Fig.8, the main gallery 13 defined in the cylinder block 4 in parallel to the crankshaft 1 is connected to an oil passage 4<sub>7</sub> defined in a surface of the cylinder block 4 mated to the lower block 5 through

an oil passage 4<sub>8</sub> defined in the cylinder block 4. The cylinder block 4 and the lower block 5 are integrally coupled to each other by a plurality of bolts 51 and the two bolts 30, 30 for coupling the balancer holder 29 to the lower block 5. The oil passage 4<sub>7</sub> in the mated surface of the cylinder block 4 communicates with lubricating oil passages 29<sub>3</sub>, 29<sub>4</sub>, and 29<sub>5</sub> defined in the balancer holder 29 through oil passages 5<sub>6</sub> and 29<sub>2</sub> defined between the lower block 5 as well as the balancer holder 29 and an outer periphery of one of the two bolts 30, 30. The oil passage 4<sub>7</sub> in the mated surface of the cylinder block 4 also communicates with an oil channel 4<sub>8</sub> surrounding a part of the #3 journal portion 1<sub>3</sub> of the crankshaft 1 to lubricate the #3 journal portion 1<sub>3</sub>.

[0026] A bearing cap 61<sub>3</sub> (see Fig.8) made of an iron-based material is embedded in the lower block 5 made of an aluminum-based material, and the bearing cap 61<sub>3</sub> and the balancer holder 29 made of the iron-based material are commonly clamped to the cylinder block 4 made of an aluminum-based material. Therefore, the weight of the lower block 5 can be reduced, and the supporting rigidity for the crankshaft 1 and both the balancer shafts 21 and 22 can be remarkably enhanced. Bolts 51, 51 for fixing the bearing cap 61<sub>3</sub> made of the iron-based material in the vicinity of the crankshaft 1 and the bolts 30, 30 for fixing the bearing cap 61<sub>3</sub> and the balancer holder 29 made of the iron-based material at portions outside of the bolts 51, 51 are disposed in parallel to each other. Moreover, an oil passage 4<sub>6</sub> for lubricating the balancer shafts 21 and 22 are defined between both the bolts 51 and 30. Therefore, the cylinder block 4 and the lower block 5 can be formed in a compact manner.

[0027] As can be seen from Fig.9, two bearing bores 29<sub>6</sub> and 29<sub>7</sub> are provided in the balancer holder 29 for mounting of a first bearing bushing 52<sub>a</sub> and a second bearing bushing 52<sub>b</sub> which support the front and rear balancer shafts 21 and 22, respectively. The lubricating oil passages 29<sub>3</sub>, 29<sub>4</sub> and 29<sub>5</sub> are cut from the right side to the left side in Fig.9 by a single drill and extend through the two bearing bores 29<sub>6</sub> and 29<sub>7</sub> to the oil passage 29<sub>2</sub> defined around the outer periphery of the bolt 30. Axes L of the lubricating oil passages 29<sub>3</sub>, 29<sub>4</sub> and 29<sub>5</sub> are oriented eccentrically upwards by a predetermined distance  $\delta$  from centers O, O of the bearing bores 29<sub>6</sub> and 29<sub>7</sub> (i.e., centers O, O of the front and rear balancer shafts 21 and 22).

[0028] Each of the first and second bearing bushings 52<sub>a</sub> and 52<sub>b</sub> mounted in the two bearing bores 29<sub>6</sub> and 29<sub>7</sub> in the balancer holder 29 is made of the same material and has a first oil bore 52<sub>a1</sub>, 52<sub>b1</sub> and a second oil bore 52<sub>a2</sub>, 52<sub>b2</sub> at locations spaced apart from each other by a center angle  $\theta$  different from 180°, as shown in Fig.10. Each of the first and second bearing bushings 52<sub>a</sub> and 52<sub>b</sub> has a notch 52<sub>3</sub> defined in a side edge thereof, which is adapted to be engaged by a projection of a press-fit jig to limit the phase of the bearing bushings 52<sub>a</sub> and 52<sub>b</sub> when the bearing bushings 52<sub>a</sub> and 52<sub>b</sub> are press-fitted into the bearing bores 29<sub>6</sub> and 29<sub>7</sub>.

[0029] The first upstream end-side bearing bushing 52<sub>a</sub> mounted in the bearing bore 29<sub>6</sub> to support the main journal portion 26<sub>3</sub> of the rear balancer shaft 22 is disposed so that the first and second oil bores 52<sub>a1</sub> and 52<sub>a2</sub> defined therein communicate with the lubricating oil passages 29<sub>3</sub> and 29<sub>4</sub>, respectively. The second downstream end-side bearing bushing 52<sub>b</sub> mounted in the bearing bore 29<sub>7</sub> to support the main journal portion 23<sub>3</sub> of the front balancer shaft 21 is disposed so that the first oil bore 52<sub>b1</sub> communicates with the lubricating oil passage 29<sub>4</sub> and the second oil bore 52<sub>b2</sub> is closed to keep out of the lubricating oil passage 29<sub>5</sub>. An annular oil channel 26<sub>6</sub> is defined around the outer periphery of the main journal portion 26<sub>3</sub> of the rear balancer shaft 22, and the two oil bores 52<sub>a1</sub> and 52<sub>a2</sub> in the first bearing bushing 52<sub>a</sub> communicate with each other through the oil channel 26<sub>6</sub>. Because the annular oil channel 26<sub>6</sub> is defined, the amount of lubricating oil supplied to the bearing bushing 52<sub>b</sub> located at the downstream end can be assured.

[0030] As can be seen from Figs.1 and 4, a pump follower sprocket 33 and a balancer follower sprocket 34 are fixed to the axial end of the pump shaft 16 extending from the pump body 11 and the axial end of the front balancer shaft 21, respectively. Both the sprockets 33 and 34 are connected through an endless chain 36 to a driving sprocket 35 fixed to the axial end of the crankshaft 1. A chain guide 37 is mounted on the tensioned side of the endless chain 36, and a hydraulic chain tensioner 38 is mounted on the loosened side of the endless chain 36.

[0031] The balancer follower sprocket 34 has one-half the number of teeth of the driving sprocket 35, and the pump follower sprocket 33 has a number of teeth which is different from the number of teeth of the balancer follower sprocket 34. It is preferable for performance of the oil pump 7 that the balancer follower sprocket 34 has a smaller number of teeth than the pump follower sprocket 33. The endless chain 36 for driving the oil pump 7 and the front balancer shaft 21 is disposed inside an endless chain 36a for driving a camshaft, namely, on the side of the #1 journal portion 1<sub>1</sub> of the crankshaft 1.

[0032] The operation of the embodiment of the present invention having the above-described arrangement will be described below.

[0033] When the engine E is driven, the rotation of the crankshaft 1 is transmitted through the driving sprocket 35 and the endless chain 36 to the pump follower sprocket 33 and the balancer follower sprocket 34. Since the balancer follower sprocket 34 has one-half the number of teeth of the driving sprocket 35, the front balancer shaft 21 and the rear balancer shaft 22 connected to the front balancer shaft 21 through the driving helical gear 23<sub>5</sub> and the follower helical gear 26<sub>5</sub> having the same number of teeth are rotated in opposite directions at a speed twice that of the crankshaft 1 to alleviate the secondary vibration of the engine E. In addition, since the pump follower sprocket 33 has a number of teeth

which is different from the number of teeth of the balancer follower sprocket 34, the pump shaft 16 is rotated at a speed different from the number of revolutions of the balancer shafts 21 and 22 (e.g., at a speed one-half the speed of the balancer shafts 21 and 22).

[0034] In this way, the pump shaft 16 and the rear balancer shaft 22 disposed below the cylinder block 4 are disposed coaxially in a separated manner and driven independently. Therefore, the size of the oil pump 7 cannot be increased and moreover, not only the oil pump 7 and the rear balancer shaft 22 can be disposed in a compact manner below the cylinder block 4, but also the speed of the oil pump 7 can be set at a value unrelated to the speed of the rear balancer shaft 22 to maintain freedom of design. The pump shaft 16 and the rear balancer shaft 22 are not necessarily to be disposed exactly coaxially with each other, but if the reduction in size and design freedom of the engine E are taken into consideration, it is desirable that the pump shaft 16 and the rear balancer shaft 22 are disposed coaxially with each other, as in the embodiment.

[0035] As can be seen from Fig.4, since the oil supply channel 12<sub>5</sub> is defined in the surface of the pump cover 12 opposed to the pump shaft 16 and communicates at one end with the discharge port 11<sub>2</sub> of the oil pump 7 and at the other end with the axial oil passage 12<sub>4</sub> defined in the pump cover 12, the oil supplied from the discharge port 11<sub>2</sub> through the oil supply channel 12<sub>4</sub> is supplied via the axial oil passage 12<sub>4</sub> to the oil chamber 12<sub>3</sub> to lubricate the bracing journal portion 26<sub>4</sub> of the rear balancer shaft 22 supported in the bearing bore 12<sub>2</sub> connected to the oil chamber 12<sub>3</sub>. Because the oil passage 12<sub>4</sub> is defined in the pump cover 12 in the above manner, the bracing journal portion 26<sub>4</sub> of the rear balancer shaft 22 can be lubricated through the oil passage having a minimum length.

[0036] The rear balancer shaft 22 is biased in a direction of an arrow A in Fig.4 by a reaction force received by the follower helical gear 26<sub>5</sub> of the rear balancer shaft 22 from the driving helical gear 23<sub>5</sub> of the front balancer shaft 21. However, the axial end of the bracing journal portion 26<sub>4</sub> of the rear balancer shaft 22 is biased in a direction of an arrow B by a hydraulic pressure applied to the oil chamber 12<sub>3</sub> through the oil supply channel 12<sub>5</sub> and the axial oil passage 12<sub>4</sub> defined in the pump cover 12 and hence, the movement of the rear balancer shaft 22 in the thrust direction can be restrained to prevent abnormal sound generation.

[0037] Now, the oil supplied from the oil pump 7 to the main gallery 13 in the cylinder block 4 is supplied via the oil passages 4<sub>6</sub> and 4<sub>7</sub> in the cylinder block 4, the oil passage 5<sub>6</sub> in the lower block 5 and the oil passage 29<sub>2</sub> in the balancer holder 29 to the lubricating oil passage 29<sub>3</sub> in the balancer holder 29. The oil supplied to the lubricating oil passage 29<sub>3</sub> passes through the first oil bore 52<sub>a1</sub> in the first bearing bushing 52<sub>a</sub> of the rear balancer shaft 22 to lubricate the main journal portion 26<sub>3</sub> of the rear balancer shaft 22. Such oil is supplied

through the oil channel 26<sub>6</sub> defined in the main journal portion 26<sub>3</sub> and the second oil bore 52<sub>a2</sub> in the first bearing bushing 52<sub>a</sub> to the lubricating oil passage 29<sub>4</sub> in the balancer holder 29. The oil supplied to the lubricating oil passage 29<sub>4</sub> passes through the first oil bore 52<sub>b1</sub> in the second bearing bushing 52<sub>b</sub> of the front balancer shaft 21 to lubricate the main journal portion 23<sub>3</sub> of the front balancer shaft 21.

**[0038]** At this time, the oil which has lubricated the main journal portion 23<sub>3</sub> of the front balancer shaft 21 is prevented from entering the lubricating oil passage 29<sub>5</sub>, because the second oil bore 52<sub>b2</sub> in the second bearing bushing 52<sub>b</sub> of the front balancer shaft 21 is closed to keep out of the lubricating oil passage 29<sub>5</sub> in the balancer holder 29, as can be seen from Fig.9. Even if the same material is used for the first bearing bushing 52<sub>a</sub> of the front balancer shaft 21 and the second bearing bushing 52<sub>b</sub> of the rear balancer shaft 22 to reduce the number of types of parts, the end opening of the lubricating passage 29<sub>5</sub> need not be occluded by a special member such as a blind plug, which can contribute to a reduction in number of parts.

**[0039]** In addition, since the oil passages 5<sub>6</sub> and 29<sub>2</sub> for guiding the oil to the lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub> are made utilizing the bolt bores in the bolts 30 for coupling the lower block 5 and the balancer holder 29 to the cylinder block 4, the oil passages 5<sub>6</sub> and 29<sub>2</sub> can be easily made. Moreover, since the lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub> in the balancer holder 29 are defined offset above the centers O, O of the bearing bores 29<sub>6</sub> and 29<sub>7</sub> (on the side of the lower block 5), the length of the oil passage 29<sub>2</sub> in the balancer holder 29 can be shortened to the minimum, but also the positions of the seating faces of the bolts 30, 30 can be shifted upwards to contribute to the reduction in size of the engine E. This is convenient particularly when the rear side of the oil pan 6 (below the rear balancer shaft 22) is shallower than the front side of the oil pan 6 (below the front balancer shaft 21), as shown in Fig.1.

**[0040]** In the embodiment shown in Fig.9, all of the three oil bores 52<sub>a1</sub>, 52<sub>a2</sub> and 52<sub>b1</sub> in the bearing bushings 52<sub>a</sub> and 52<sub>b</sub> open into the lubricating oil passages 29<sub>3</sub> and 29<sub>4</sub> and hence, it is unnecessary to enlarge the oil bores 52<sub>a1</sub>, 52<sub>a2</sub> and 52<sub>b1</sub> more than required. Thus, the sizes of the oil bores 52<sub>a1</sub>, 52<sub>a2</sub> and 52<sub>b1</sub> can be set depending upon the amount of the lubricating oil, while a sufficient rigidity of the oil bushings 52<sub>a</sub>, 52<sub>b</sub> is assured, thereby enhancing the freedom of design.

**[0041]** Fig.11 illustrates a second embodiment of the present invention. In this second embodiment, lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub> in the balancer holder 29 are defined offset above the centers O, O of the bearing bores 29<sub>6</sub> and 29<sub>7</sub>, and first oil bores 52<sub>a1</sub> and 52<sub>b1</sub> and second oil bores 52<sub>a2</sub> and 52<sub>b2</sub> defined respectively in two bearing bushings 52<sub>a</sub> and 52<sub>b</sub> made of the same material have a center angle equal to 180°. Even with the second embodiment, a function and effect similar to those in the first embodiment can be provided by the

fact that the two oil bores 52<sub>a1</sub> and 52<sub>a2</sub> in the first bearing bushing 52<sub>a</sub> of the rear balancer shaft 22 communicate with the lubricating oil passages 29<sub>3</sub> and 29<sub>4</sub>; the first oil bore 52<sub>b1</sub> in the second bearing bushing 52<sub>b</sub> of the front balancer shaft 21 communicates with the lubricating oil passage 29<sub>4</sub>, and the second oil bore 52<sub>b2</sub> is closed to keep out of the lubricating oil passage 29<sub>5</sub>. Moreover, since the center angle  $\theta$  formed by the first and second oil bores 52<sub>a1</sub>, 52<sub>b1</sub> and 52<sub>a2</sub>, 52<sub>b2</sub> in the bearing bushings 52<sub>a</sub> and 52<sub>b</sub> is 180°, it is easy to cut the oil bores 52<sub>a1</sub>, 52<sub>b1</sub>, 52<sub>a2</sub> and 52<sub>b2</sub>.

**[0042]** Fig.12 illustrates a third embodiment of the present invention. In the third embodiment, lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub> in the balancer holder 29 are defined to extend through the centers O, O of the bearing bores 29<sub>6</sub> and 29<sub>7</sub>, and first and second oil bores 52<sub>a1</sub>, 52<sub>b1</sub>, 52<sub>a2</sub> and 52<sub>b2</sub> defined in two bearing bushings 52<sub>a</sub> and 52<sub>b</sub> made of the same material have a center angle  $\theta$  different from 180°. Even with the third embodiment, a function and an effect similar to those in the first embodiment can be provided by the fact that the two oil bores 52<sub>a1</sub> and 52<sub>a2</sub> in the first bearing bushing 52<sub>a</sub> of the rear balancer shaft 22 communicate with the lubricating oil passages 29<sub>3</sub> and 29<sub>4</sub>; the first oil bore 52<sub>b1</sub> in the second bearing bushing 52<sub>b</sub> of the front balancer shaft 21 communicates with the lubricating passage 29<sub>4</sub>, and the second oil bore 52<sub>b2</sub> is closed to keep out of the lubricating oil passage 29<sub>5</sub>. Moreover, since the lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub> extend through the centers O, O of the bearing bores 29<sub>6</sub> and 29<sub>7</sub>, it is easy to cut the lubricating oil passages 29<sub>3</sub> to 29<sub>5</sub>.

**[0043]** Although the embodiments of the present invention have been described in detail, it will be understood that the present invention is not limited to the above-described embodiments, and various modifications may be made without departing from the scope of the invention defined in the claims.

**[0044]** For example, the structure for lubricating the balancer shafts 21 and 22 has been described and illustrated in the embodiments, but the present invention is applicable to the lubrication of any other shafts and moreover, the number of such shafts may be three or more.

**[0045]** An engine has two balancer shafts supported on two bearing bushings which are made of the same material and mounted to a balancer holder. Lubricating oil passages for supplying oil to the bearing bushings are defined offset upwards from the centers O of the bearing bushings and by a distance  $\delta$ . Each of the bearing bushings has two oil bores having a center angle  $\theta$  other than 180°. The two oil bores in the bearing bushing of one balancer shaft communicate with the lubricating oil passages, and one of the oil bores in the bearing bushing of another balancer shaft communicates with the lubricating oil passage, while the other oil bore of that another balancer shaft is closed to keep out of the lubricating oil passage. Thus, downstream ends of the lubricating oil passages for supplying the oil to the bearing bushings

of the plurality of rotary shafts can be closed without use of a special closing member such as a blind plug.

#### Claims

1. A rotary shaft lubricating structure for lubricating a plurality of rotary shafts by supplying an oil from an upstream side to a downstream side of a lubricating oil passage defined in a bearing block, comprising:

a plurality of bearing bores, said lubricating oil passage passing through said plurality of bearing bores; and

a plurality of annular bearing members, said rotary shafts being supported respectively in said plurality of annular bearing members at least one of which has first and second oil bores spaced apart from one another through a predetermined angle and which bearing members are fixed in said plurality of bearing bores defined in the bearing block,

wherein said first and second oil bores in the bearing members excluding a downstream end-side bearing member located at a downstream end in an oil supplying direction open into said lubricating oil passage,

wherein an upstream-side oil bore in said downstream end-side bearing member opens into said lubricating oil passage, characterised by

a downstream-side oil bore in the said downstream end-side bearing member which downstream-side oil bore is closed by said bearing block to keep out of said lubricating oil passage.

2. A rotary shaft lubricating structure according to claim 1,

wherein said bearing block is coupled by a bolt to a body block having an oil passage for supplying the oil to said lubricating oil passage, wherein another oil passage is defined around an outer periphery of a bolt bore, through which said bolt is inserted, to communicate with said lubricating oil passage in said bearing block, and

wherein said lubricating oil passage in said bearing block is defined offset from the center of said bearing bore toward said body block.

3. A rotary shaft lubricating structure according to claim 2,

wherein said first and second oil bores are spaced apart from each other through an angle other than 180°.

4. A rotary shaft lubricating structure according to

claim 2,

wherein said first and second oil bores are spaced apart from each other through an angle equal to 180°.

5. A rotary shaft lubricating structure according to claim 1, wherein said bearing block is coupled by a bolt to a body block having an oil passage for supplying the oil to said lubricating oil passage,

wherein an oil passage is defined around an outer periphery of a bolt bore, through which said bolt is inserted, so as to communicate with said lubricating oil passage in said bearing block,

wherein said lubricating oil passage in said bearing block is defined to extend through the center of said bearing bore, and

wherein said first and second oil bores are spaced apart from each other through an angle different from 180°.

6. A rotary shaft lubricating structure according to claim 1,

wherein said bearing block comprises a balancer shaft support member coupled to a lower surface of the cylinder block of an engine through a lower block,

wherein said rotary shaft comprises a balancer shaft supported on said balancer shaft support member,

wherein said lower block having a bearing cap for supporting a journal portion of a crankshaft is placed into abutment against opposite side-walls of said cylinder block, said balancer shaft support member being placed into abutment against a lower surface of said lower block, said lower block and said balancer shaft support member being commonly clamped to said cylinder block by a common bolt, and

wherein a bore through which said bolt is inserted is utilized as an oil passage for supplying the oil to said lubricating oil passage.

7. A rotary shaft lubricating structure according to claim 6,

wherein said lubricating oil passage is defined offset from the center of said bearing bore toward said lower block.

8. A rotary shaft lubricating structure according to claim 1,

wherein said bearing block comprises a balancer shaft support member coupled to a lower surface of the cylinder block of an engine through a lower block,

wherein said rotary shaft comprises a balancer shaft supported on said balancer shaft support member,

wherein said lower block is made of an aluminum-based material and includes a bearing cap made of an iron-based material and embedded therein for supporting a journal portion of a crankshaft,

wherein said lower block is fixed to opposite sidewalls of said cylinder block which is made of an aluminum-based material,

wherein said balancer shaft support member being fixed to a lower surface of said lower block, and

wherein an oil passage for supplying the oil to the journal portion of the crankshaft is defined in a surface of said cylinder block to which said lower block is coupled and which is opposed to said bearing cap, said oil passage diverging from an oil passage for supplying the oil to said lubricating oil passage in said balancer shaft support member.

9. A rotary shaft lubricating structure according to claim 6,

wherein said lubricating oil passage is defined offset from the center of said bearing bore toward said lower block.

#### Patentansprüche

1. Drehwellen-Schmierungsstruktur zum Schmieren einer Mehrzahl drehender Wellen durch Ölzufuhr von einer stromaufwärtigen Seite zu einer stromabwärtigen Seite einer in einem Lagerblock gebildeten Schmierölpassage, umfassend:

eine Mehrzahl von Lagerbohrungen, wobei die Schmierölpassage durch die Mehrzahl von Lagerbohrungen hindurchgeht; und

eine Mehrzahl ringförmiger Lagerelemente, wobei die drehenden Wellen jeweils in der Mehrzahl ringförmiger Lagerelemente gehalten sind, von denen zumindest eines eine erste und eine zweite Ölbohrung aufweist, die um einen vorbestimmten Winkel mit Abstand voneinander angeordnet sind, und wobei die Lagerelemente in der Mehrzahl von in dem Lagerblock gebildeten Lagerbohrungen befestigt sind,

wobei sich die erste und die zweite Ölbohrung in den Lagerelementen außer einem am stromabwärtigen Ende gelegenen Lagerelement, das sich an einem stromabwärtigen Ende in Ölzufuhrrichtung befindet, in die Schmierölpassage öffnen,

wobei sich eine stromaufwärtige Ölbohrung in

dem am stromabwärtigen Ende gelegenen Lagerelement in die Schmierölpassage öffnet,

gekennzeichnet durch

eine stromabwärtige Ölbohrung in dem am stromabwärtigen Ende gelegenen Lagerelement, wobei die stromabwärtige Ölbohrung durch den Lagerblock verschlossen ist, so dass sie außerhalb der Schmierölpassage bleibt.

2. Drehwellen-Schmierungsstruktur nach Anspruch 1,

wobei der Lagerblock durch einen Bolzen mit einem Körperblock verbunden ist, der eine Ölpassage zur Ölzufuhr zu der Schmierölpassage aufweist,

wobei eine andere Ölpassage um einen Außenumfang einer Bolzenbohrung, durch die der Bolzen eingesetzt ist, herum ausgebildet ist, um mit der Schmierölpassage in dem Lagerblock in Verbindung zu stehen, und wobei die Schmierölpassage in dem Lagerblock von der Mitte der Lagerbohrung zu dem Körperblock hin versetzt ausgebildet ist.

3. Drehwellen-Schmierungsstruktur nach Anspruch 2, wobei die erste und die zweite Ölbohrung um einen von 180° abweichenden Winkel mit Abstand voneinander angeordnet sind.

4. Drehwellen-Schmierungsstruktur nach Anspruch 2, wobei die erste und die zweite Ölbohrung um einen Winkel gleich 180° mit Abstand voneinander angeordnet sind.

5. Drehwellen-Schmierungsstruktur nach Anspruch 1,

wobei der Lagerblock durch einen Bolzen mit einem Körperblock verbunden ist, der eine Ölpassage zur Ölzufuhr zu der Schmierölpassage aufweist,

wobei eine Ölpassage um einen Außenumfang einer Bolzenbohrung, durch die der Bolzen eingesetzt ist, herum ausgebildet ist, um mit der Schmierölpassage in dem Lagerblock in Verbindung zu stehen,

wobei die Schmierölpassage in dem Lagerblock so ausgebildet ist, dass sie sich durch die Mitte der Lagerbohrung erstreckt, und

wobei die erste und die zweite Ölbohrung um einen von 180° abweichenden Winkel mit Abstand voneinander angeordnet sind.

6. Drehwellen-Schmierungsstruktur nach Anspruch 1,

wobei der Lagerblock ein Ausgleichswellen-Haltelement aufweist, das mit einer Unterseite des Zylinderblocks eines Motors durch einen



- unteren Block verbunden ist,  
wobei die drehende Welle eine Ausgleichswelle aufweist, die an dem Ausgleichswellen-Haltelement gehalten ist,  
wobei der untere Block, der eine Lagerkappe zum Halten eines Zapfenabschnitts einer Kurbelwelle aufweist, in Anlage an entgegengesetzten Seitenwänden des Zylinderblocks angeordnet ist, wobei das Ausgleichswellen-Haltelement in Anlage an einer Unterseite des unteren Blocks angeordnet ist, wobei der untere Block und das Ausgleichswellen-Haltelement durch einen gemeinsamen Bolzen gemeinsam an den Zylinderblock geklemmt sind, und wobei eine Bohrung, durch die der Bolzen eingesetzt ist, als Ölpassage zur Ölzufuhr zu der Schmierölpassage genutzt wird.
7. Drehwellen-Schmierungsstruktur nach Anspruch 6, wobei die Schmierölpassage von der Mitte der Lagerbohrung zu dem unteren Block hin versetzt ausgebildet ist.
8. Drehwellen-Schmierungsstruktur nach Anspruch 1, wobei der Lagerblock ein Ausgleichswellen-Haltelement aufweist, das mit einer Unterseite des Zylinderblocks des Motors durch einen unteren Block verbunden ist, wobei die drehende Welle eine Ausgleichswelle aufweist, die an dem Ausgleichswellen-Haltelement gehalten ist, wobei der untere Block aus Material auf Aluminiumbasis hergestellt ist und eine Lagerkappe enthält, die aus Material auf Eisenbasis hergestellt ist und darin eingebettet ist, um einen Zapfenabschnitt einer Kurbelwelle zu halten, wobei der untere Block an entgegengesetzten Seitenwänden des Zylinderblocks, der aus Material auf Aluminiumbasis hergestellt ist, befestigt ist, wobei das Ausgleichswellen-Haltelement an einer Unterseite des unteren Blocks befestigt ist, und wobei eine Ölpassage zur Ölzufuhr zu dem Zapfenabschnitt der Kurbelwelle in jener Seite des Zylinderblocks gebildet ist, mit der der untere Block verbunden ist und die der Lagerkappe gegenüberliegt, wobei die Ölpassage von einer Ölpassage zur Ölzufuhr zu der Schmierölpassage in dem Ausgleichswellen-Haltelement abzweigt.
9. Drehwellen-Schmierungsstruktur nach Anspruch 6, wobei die Schmierölpassage von der Mitte der Lagerbohrung zu dem unteren Block hin versetzt ausgebildet ist.

## Revendications

- Structure de lubrification d'arbre rotatif destinée à la lubrification d'une pluralité d'arbres rotatifs en fournissant de l'huile à partir d'un côté amont jusqu'à un côté aval d'un passage d'huile de lubrification défini dans un bloc de palier, comprenant :  
  
une pluralité d'alésages de palier, ledit passage d'huile de lubrification passant au travers de ladite pluralité d'alésages de palier ; et  
une pluralité d'éléments de palier annulaires, lesdits arbres rotatifs étant respectivement supportés dans ladite pluralité d'éléments de palier annulaires dont au moins l'un d'entre eux comporte un premier et un second alésage de passage d'huile séparés l'un de l'autre d'un angle prédéterminé, lesquels éléments de palier sont fixés dans ladite pluralité d'alésages de palier définis dans le bloc de palier, dans laquelle lesdits premier et second alésages de passage d'huile aménagés dans les éléments de palier, à l'exception d'un élément de palier du côté de l'extrémité aval situé à une extrémité aval dans un sens d'alimentation en huile s'ouvrent dans ledit passage d'huile de lubrification, dans laquelle un alésage de passage d'huile côté amont dans ledit élément de palier côté extrémité aval s'ouvre dans ledit passage d'huile de lubrification, caractérisée par un alésage de passage d'huile côté aval dans ledit élément de palier côté extrémité aval, lequel alésage de passage d'huile côté aval est fermé par ledit bloc de palier afin de rester en dehors dudit passage d'huile de lubrification.
- Structure de lubrification d'arbre rotatif selon la revendication 1, dans laquelle ledit bloc de palier est couplé au moyen d'un boulon à un bloc principal comportant un passage d'huile destiné à alimenter en huile ledit passage d'huile de lubrification, dans laquelle un autre passage d'huile est défini autour d'une périphérie externe d'un alésage de boulon, dans lequel ledit boulon est introduit, afin de communiquer avec ledit passage d'huile de lubrification dans ledit bloc de palier, et dans laquelle ledit passage d'huile de lubrification dans ledit bloc de palier est défini de manière décalée du centre dudit alésage de palier vers ledit bloc principal.
- Structure de lubrification d'arbre rotatif selon la revendication 2, dans laquelle lesdits premier et second alésages de passage d'huile sont séparés l'un

de l'autre d'un angle autre que 180°.

4. Structure de lubrification d'arbre rotatif selon la revendication 2, dans laquelle lesdits premier et second alésages de passage d'huile sont séparés l'un de l'autre d'un angle égal à 180°. 5
5. Structure de lubrification d'arbre rotatif selon la revendication 1, dans laquelle ledit bloc de palier est couplé au moyen d'un boulon à un bloc principal comportant un passage d'huile destiné à alimenter en huile ledit passage d'huile de lubrification, 10
 

dans laquelle un passage d'huile est défini autour d'une périphérie externe d'un alésage de boulon, dans lequel ledit boulon est introduit, afin de communiquer avec ledit passage d'huile de lubrification dans ledit bloc de palier, dans laquelle ledit passage d'huile de lubrification dans ledit bloc de palier est défini de manière à s'étendre au travers du centre dudit alésage de palier, et 15

dans laquelle lesdits premier et second alésages de passage d'huile sont séparés l'un de l'autre d'un angle autre que 180°. 20 25
6. Structure de lubrification d'arbre rotatif selon la revendication 1, 30
 

dans laquelle ledit bloc de palier comprend un élément de support d'arbre d'équilibrage couplé à une surface inférieure du bloc cylindre d'un moteur par l'intermédiaire d'un bloc inférieur, 35

dans laquelle ledit arbre rotatif comprend un arbre d'équilibrage en support sur ledit élément de support d'arbre d'équilibrage, dans laquelle le bloc inférieur comportant un chapeau de palier destiné à supporter une partie de portée d'un vilebrequin est positionné en butée contre des parois latérales opposées dudit bloc cylindre, ledit élément de support d'arbre d'équilibrage étant positionné en butée contre une surface inférieure dudit bloc inférieur, ledit bloc inférieur et ledit élément de support d'arbre d'équilibrage étant fixés en commun sur ledit bloc cylindre au moyen d'un boulon commun, et 40 45

dans laquelle un alésage au travers duquel passe ledit boulon est utilisé en tant que passage d'huile afin d'alimenter en huile ledit passage d'huile de lubrification. 50
7. Structure de lubrification d'arbre rotatif selon la revendication 6, dans laquelle ledit passage d'huile de lubrification est défini de manière décalée par rapport au centre dudit alésage de palier vers ledit bloc inférieur. 55

8. Structure de lubrification d'arbre rotatif selon la revendication 1, 18

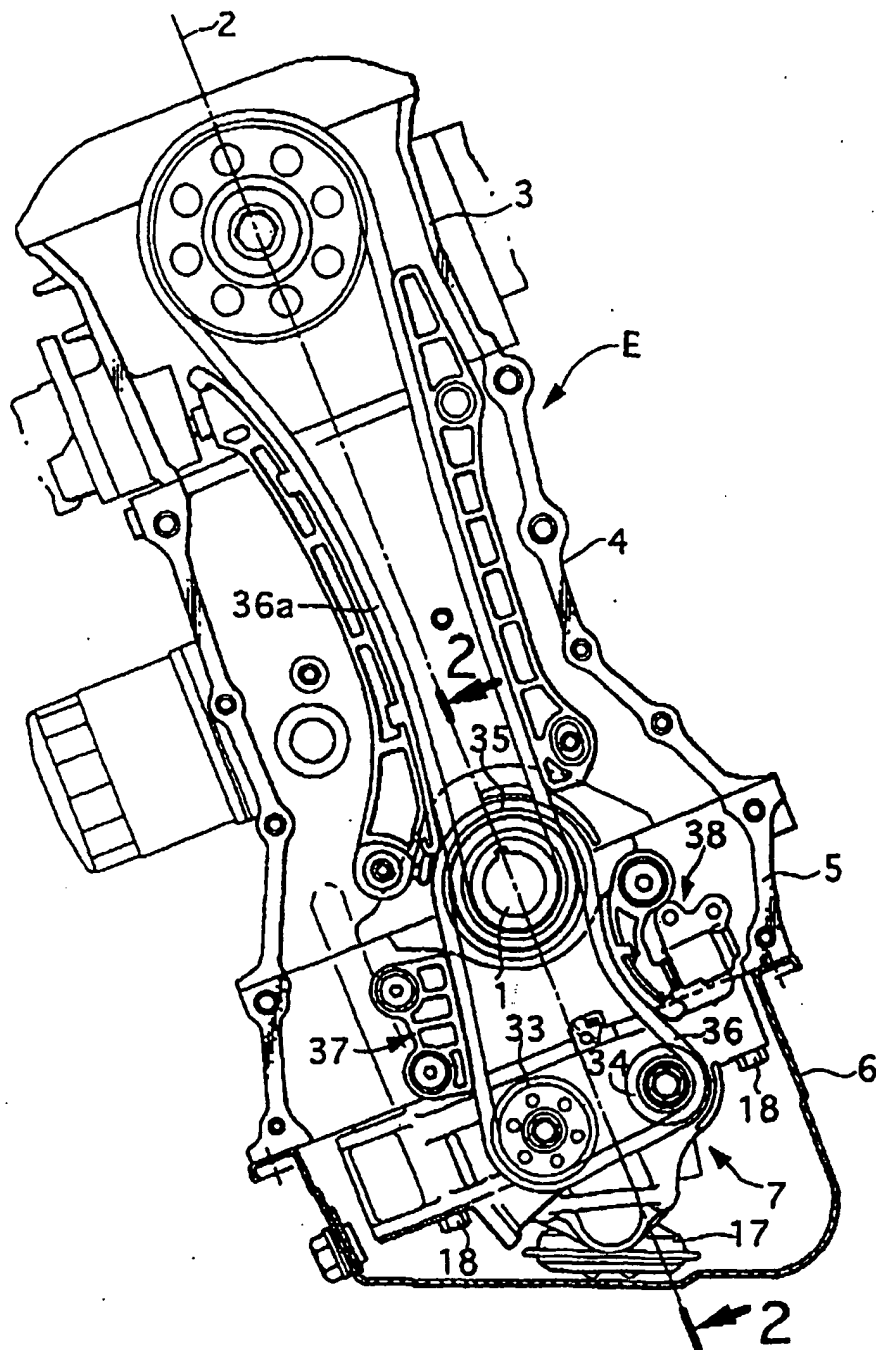
dans laquelle ledit bloc de palier comprend un élément de support d'arbre d'équilibrage couplé à une surface inférieure du bloc cylindre d'un moteur par l'intermédiaire d'un bloc inférieur, 18

dans laquelle ledit arbre rotatif comprend un arbre d'équilibrage en support sur ledit élément de support d'arbre d'équilibrage, dans laquelle le bloc inférieur est fabriqué dans un matériau à base d'aluminium et comprend un chapeau de palier fabriqué dans un matériau à base de fer et logé dans celui-ci afin de supporter une partie de portée d'un vilebrequin, dans laquelle ledit bloc inférieur est fixé sur des parois latérales opposées dudit bloc cylindre qui est fabriqué dans un matériau à base d'aluminium, 19

dans laquelle ledit élément de support d'arbre d'équilibrage est fixé sur une surface inférieure dudit bloc inférieur, et dans laquelle un passage d'huile destiné à alimenter en huile la partie de portée du vilebrequin est défini dans une surface dudit bloc cylindre auquel est couplé ledit bloc inférieur et qui est opposé au dit chapeau de palier, ledit passage d'huile étant en dérivation d'un passage d'huile destiné à alimenter en huile ledit passage d'huile de lubrification dans ledit élément de support d'arbre d'équilibrage. 20

9. Structure de lubrification d'arbre rotatif selon la revendication 6, dans laquelle ledit passage d'huile de lubrification est défini de manière décalée du centre dudit alésage de palier vers ledit bloc inférieur. 21

FIG.1



**FIG. 2**

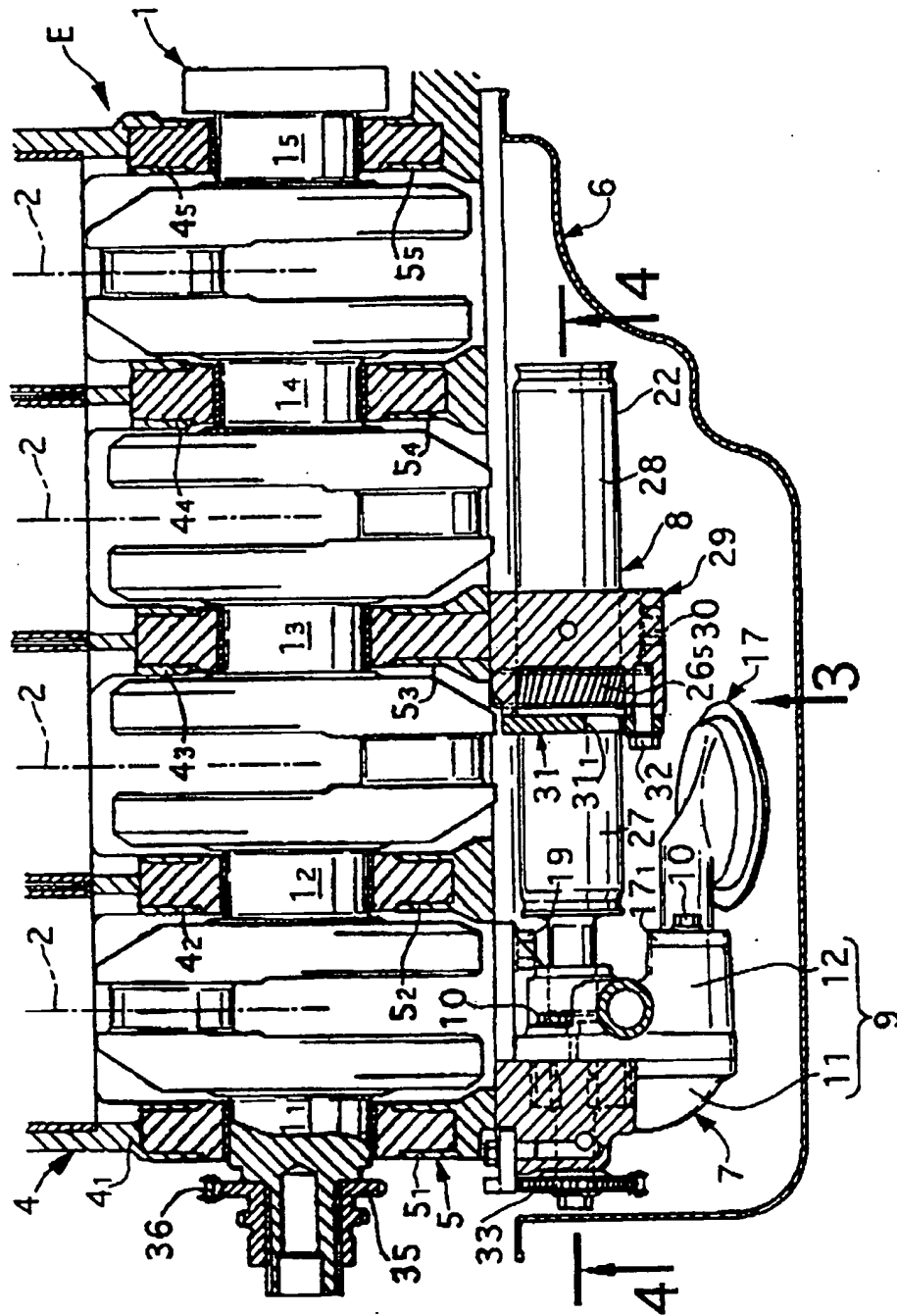


FIG.3

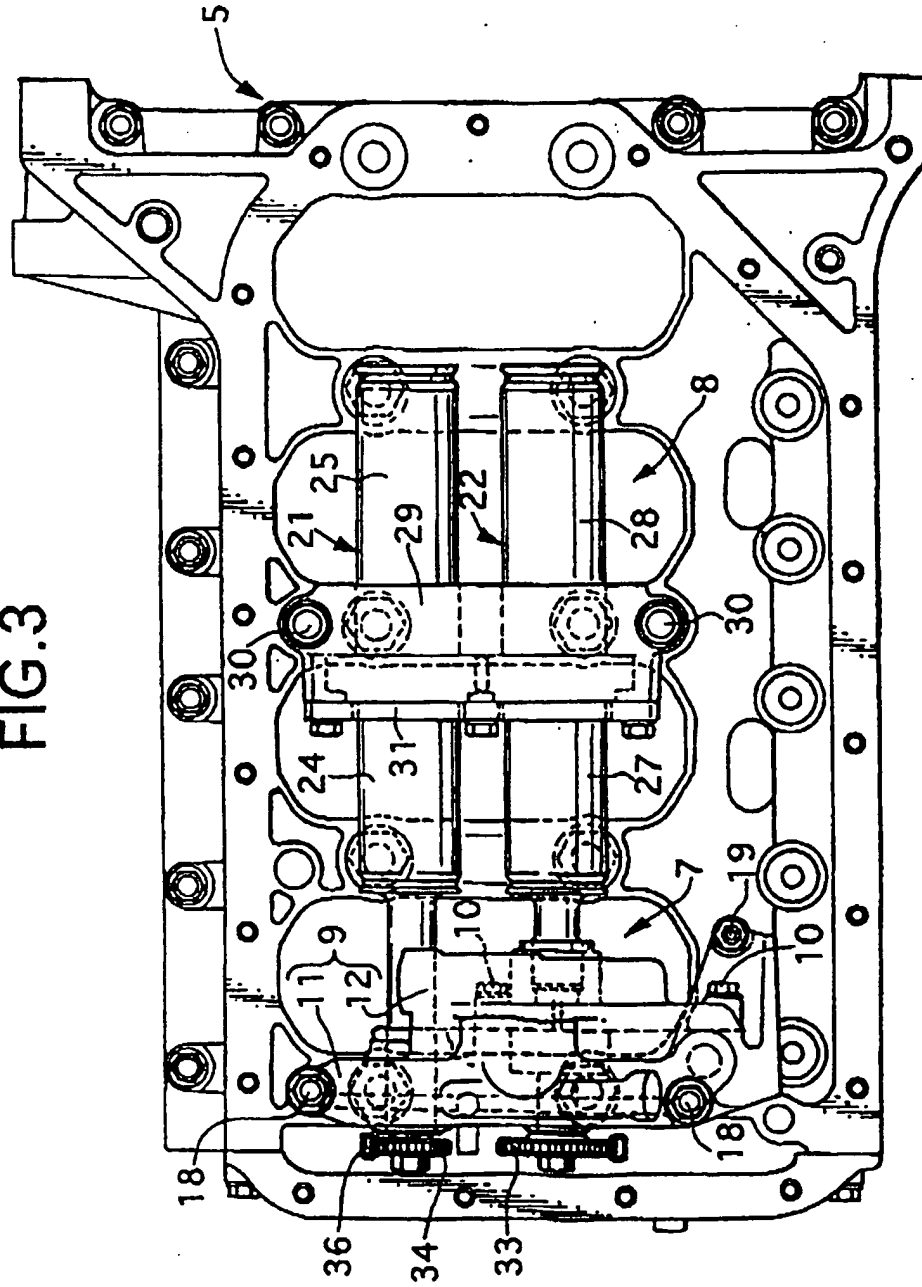


FIG.4

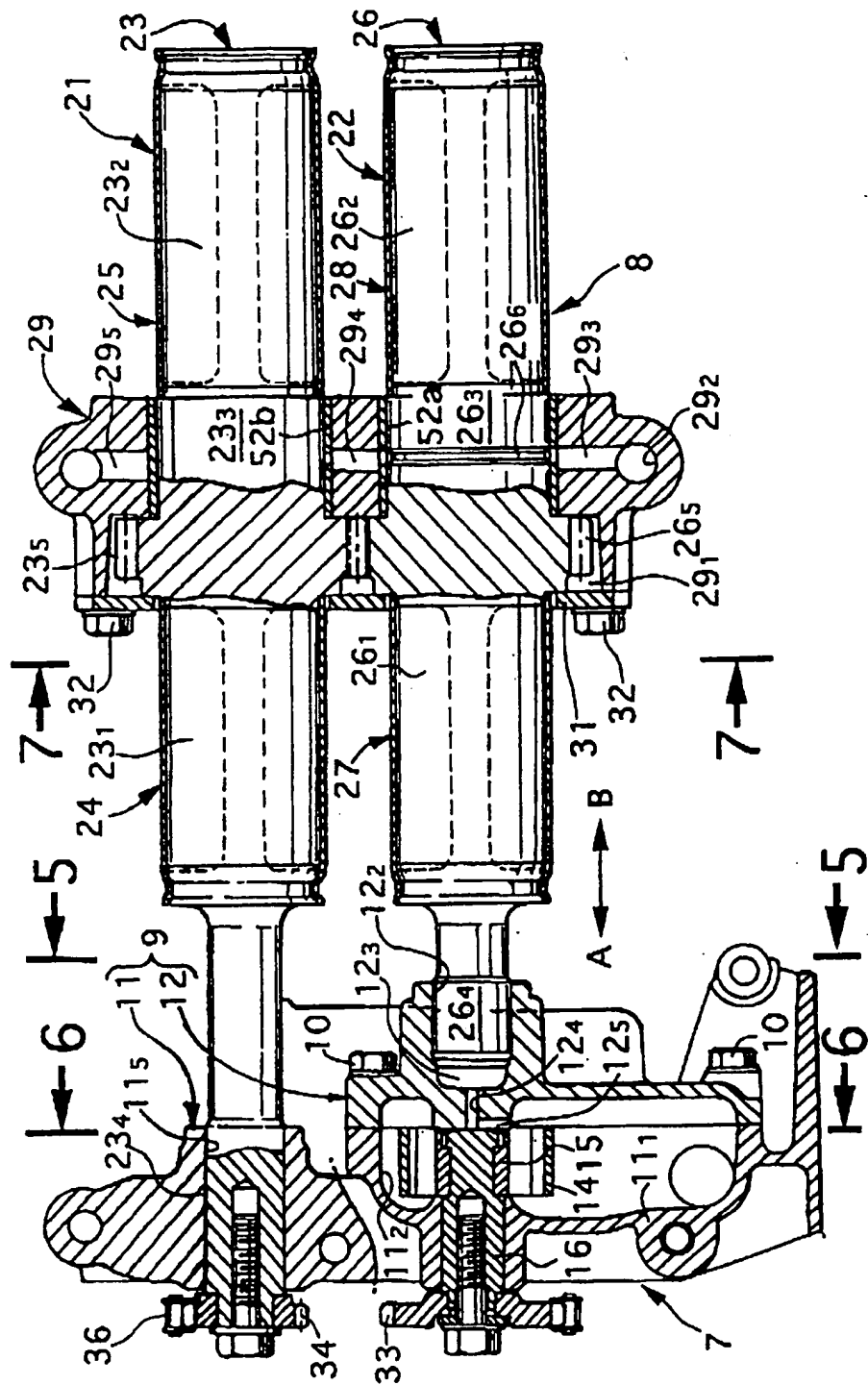


FIG.5

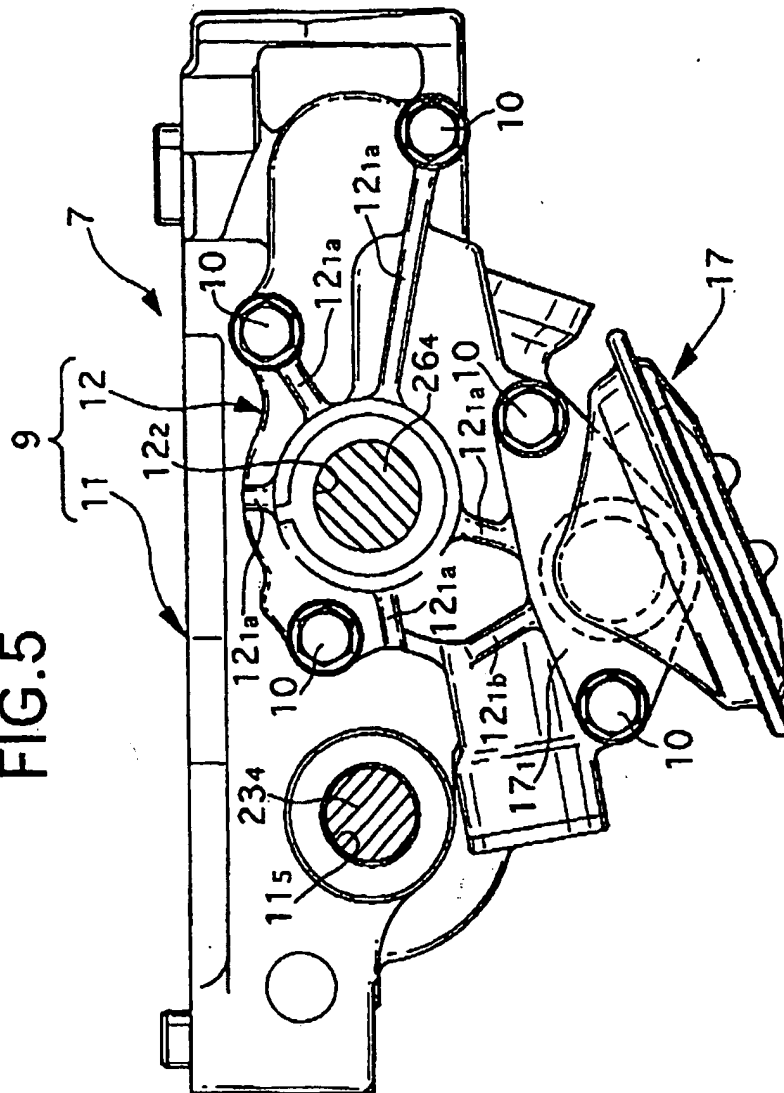


FIG.6

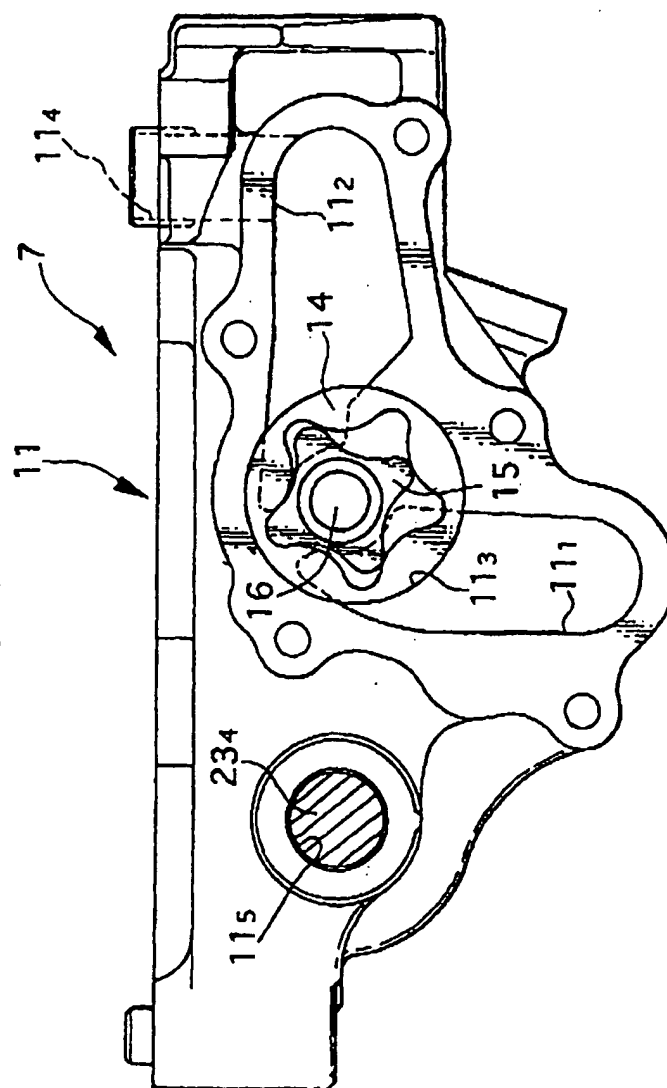




FIG.7

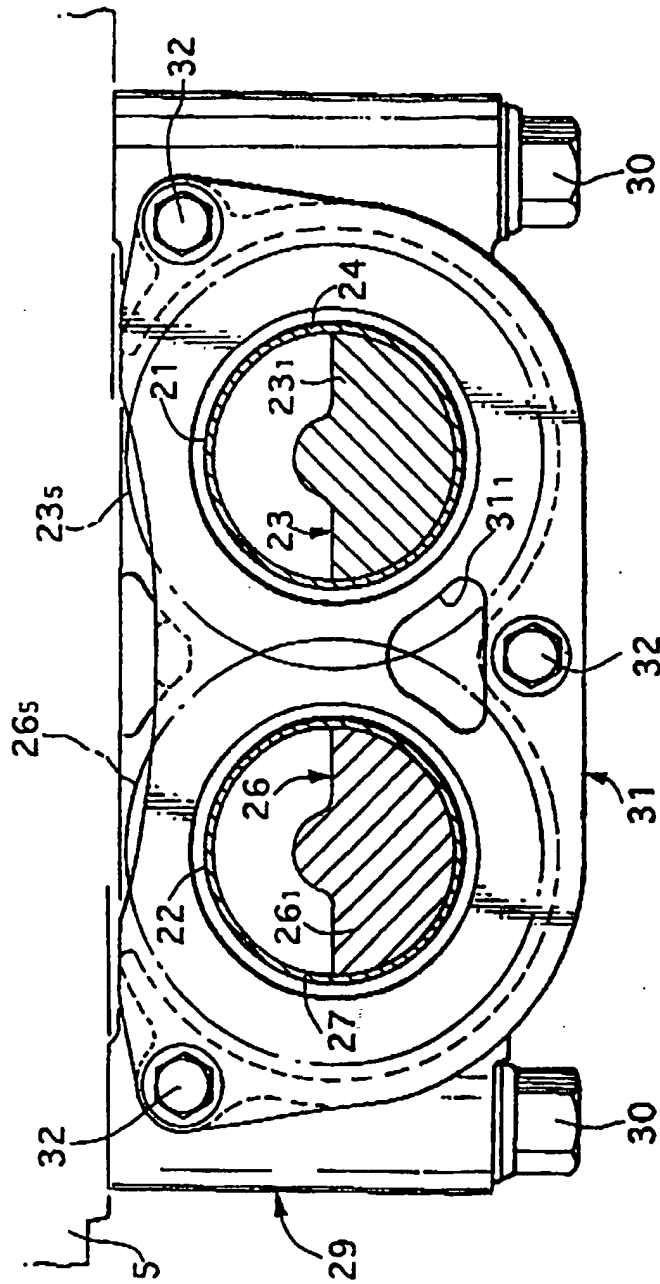


FIG.8

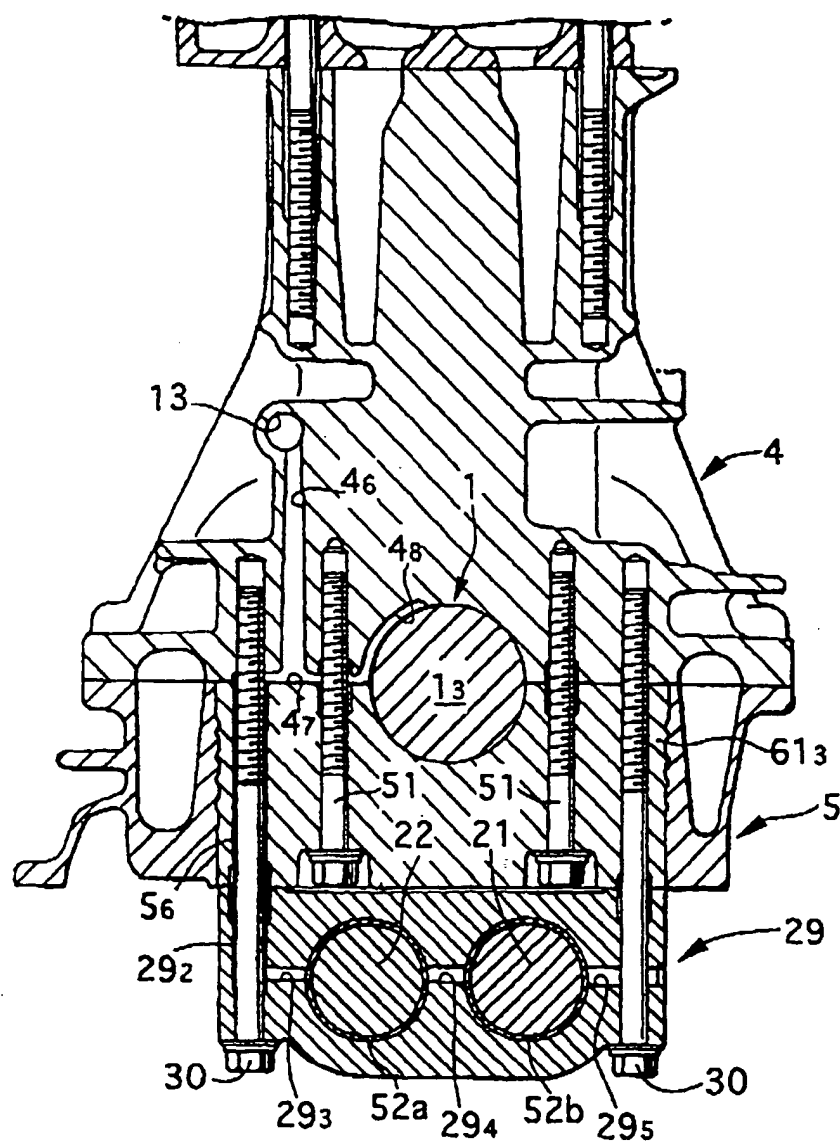


FIG.9

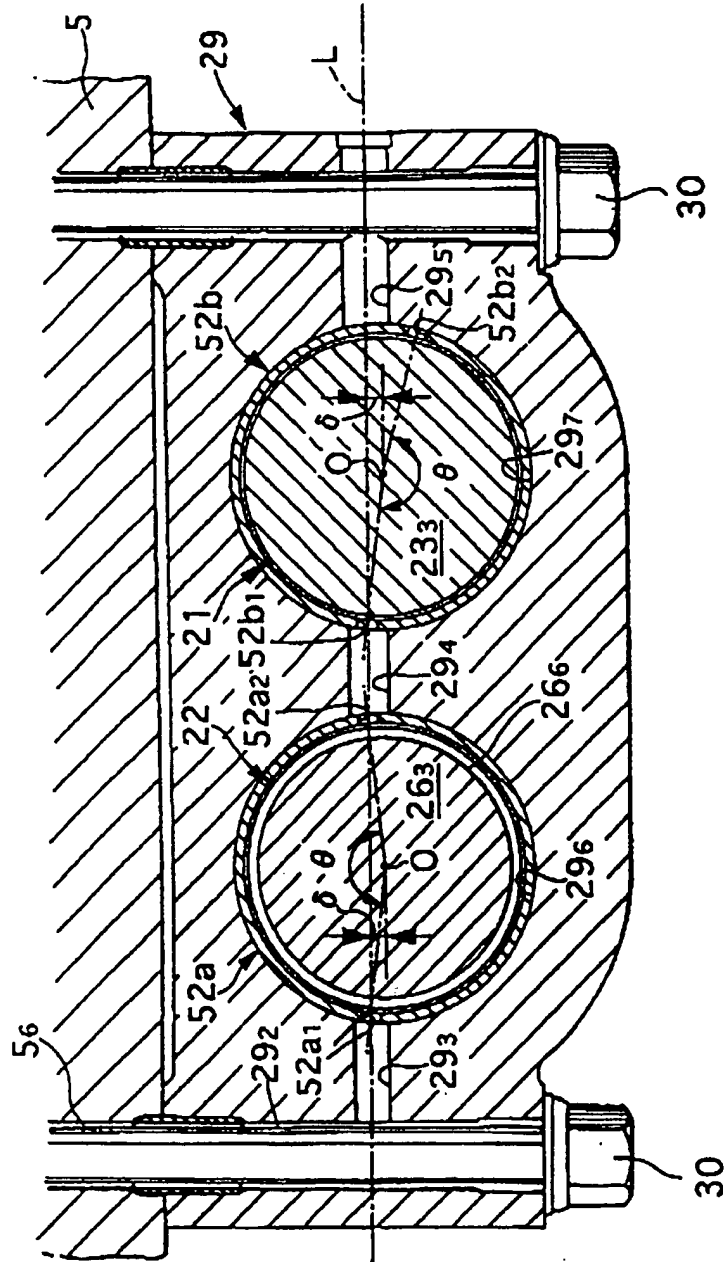


FIG.10

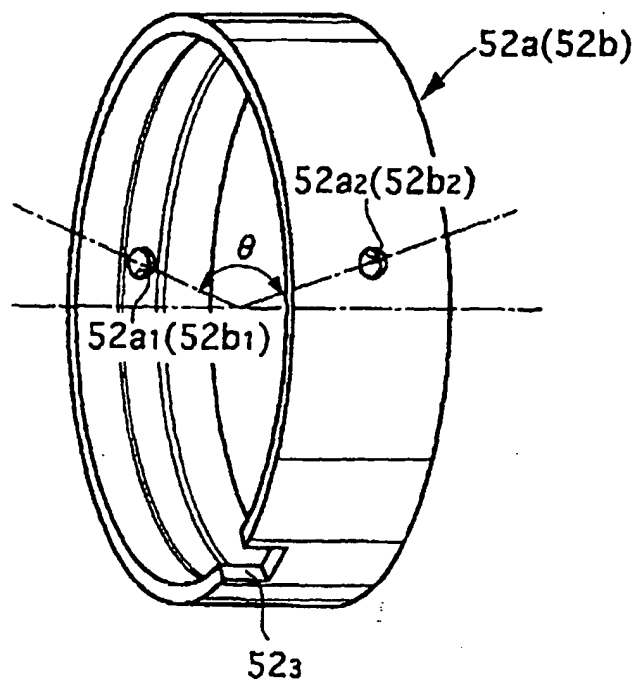


FIG.11

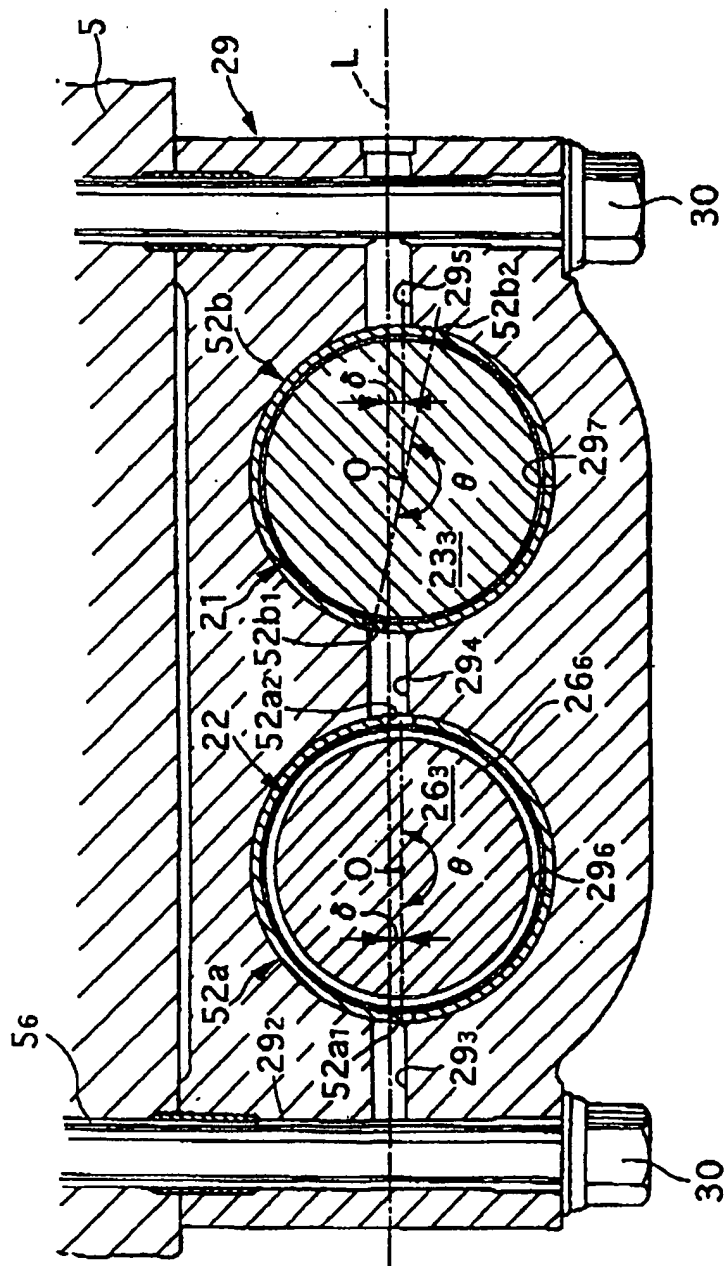


FIG.12

